

DEPARTMENT OF THE NAVY



Modeling and Simulation Verification, Validation, and Accreditation Implementation Handbook

Volume I VV&A Framework

30 March 2004

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Management Office

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EXECUTIVE SUMMARY

This is the first volume in a three volume series that provides Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A) implementation guidance in support of SECNAVINST 5200.40A, which establishes VV&A policy for the Department of the Navy (DON). Volume 1 provides high-level introductory information, the "what to do and who does it". Volume 2 will delve into the "how to do" of the "what to do" with practical application examples. Volume 3 will then provide examples of how select programs implement VV&A and their lessons learned.

The aim of this document is to provide a broad, quick overview of what the VV&A process entails. As a high level document, it is general enough to appeal to the novice as well as to seasoned VV&A implementers. The Navy Modeling and Simulation Management Office expectations for Volume 1 are for readers to gain an understanding of general VV&A concepts and that these concepts are applicable to all DON M&S programs. Lastly, the intent of the first volume is to provide enough information for key decision makers to determine when VV&A is required. Detailed implementation information and examples will be provided in subsequent volumes.

The need for M&S VV&A is even greater now as the DON assists in the development of more and more programs with the support of M&S. The fundamental argument for this increase is declining resources. The stipulation is that the models must simulate, stimulate, and emulate real world counterparts as accurately as possible to earn trust and credibility, thus instilling confidence in the users. Therefore, these models and simulations must be verified, validated, and accredited. It is feasible that over time verified, validated, and accredited models will reduce developmental cost through reuse rather than reinvention.

Although independent and separate in discussions, VV&A is linked to the M&S process as VV&A acts upon the products of the M&S process. As a result, well thought out models and simulations will evolve into solid VV&A implementations. Because of this relationship, Volume 1 describes what VV&A activities are required as an M&S program evolves and matures. This relationship is noted in sections two and three of this volume.

Subsequent sections, four and five, emphasize the need for documentation and define roles within the M&S and VV&A organizations. The documents described are minimal and essential to VV&A. As there will be other documents generated through the M&S process, they should complement and support both implementations. The suggested roles should be tailored to meet the M&S program structure based on the M&S need. VV&A is a continuous process; as the M&S evolves, so should the VV&A.

Comments are welcomed and should be submitted to vva@navmsmo.hq.navy.mil.

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1 OVERVIEW

Models include any physical, mathematical, or otherwise logical representation of a system, entity, phenomenon or process. Simulations include a method of implementing a model over time.

SECNAVINST 5200.38A, 28 February 2002

Secretary of the Navy Instruction (SECNAVINST) 5200.40A, "Verification, Validation, and Accreditation of Models and Simulations" provides amplification of and adds detail to the definition of models and simulations that require verification, validation, and accreditation (VV&A) prior to use:

- All models and simulations acquired, developed, managed, and used by Department of the Navy (DON) activities.
 - All categories of models and simulations used by DON activities including live, virtual, and constructive simulations; distributed simulations; federates and federations; emulators; prototypes, simulators; and stimulators. Models and simulations may be legacy systems, new developments, and modified or enhanced legacy modeling and simulation (M&S). These include, but are not limited to, embedded and stand-alone M&S systems.
 - Models and simulations managed by Federally Funded Research and Development Centers, industry, academia, and other Federal or non-Federal government organizations used to support a DON activity.
- Commercial-off-the-shelf, government-off-the-shelf, and new M&S tools used to train, develop, test, implement, monitor, analyze, or manage models and simulations.
- Data needed to verify M&S requirements, build the conceptual model, validate the M&S, perform experiments, and run combat support M&S decision aids.
- All M&S test resources intended to support Operational Test and Evaluation (OT&E) including new and legacy M&S, enhancements and modifications of M&S, hardware-in-the loop simulators, land-based test facilities, sea-based test facilities, threat target simulators and stimulators, and all M&S whether embedded in weapon systems, implemented as stand-alone systems, or integrated with other M&S systems for distributed simulations.

The goal of this handbook is to provide a common understanding and framework for VV&A of M&S within the DON. The framework for VV&A comprises the fundamentals of the VV&A process along with roles and responsibilities associated with implementation of the process.

The acronym "VV&A" refers to a set of three distinct, but related processes used to ensure credibility and confidence within the application of M&S results. SECNAVINST 5200.40A establishes policies and procedures and assigns responsibilities for VV&A. The instruction authorizes the publication of the Department of the Navy Modeling and Simulation Verification, Validation, and Accreditation Implementation Handbook. The information presented in the handbook provides amplification and practical guidance for those responsible for implementing VV&A. SECNAVINST 5200.40A defines VV&A as:

Verification. The process of determining that an M&S implementation and its associated data accurately represent the developer's conceptual description and specifications. *An informal question often applied to verification is "Was the M&S built right?"*

Validation. The process of determining the degree to which an M&S and its associated data are an accurate representation of the real world from the perspective of the intended use of the M&S. *The informal question often asked for validation is "Was the right M&S built?"*

Accreditation. The official determination that an M&S application and its associated data are acceptable for use for a specific purpose. *Accreditation seeks to answer the question "Is this the right M&S to use?"*

Figure 1 provides a simple pictorial explanation of the terms "verification", "validation", and "accreditation" defined above.

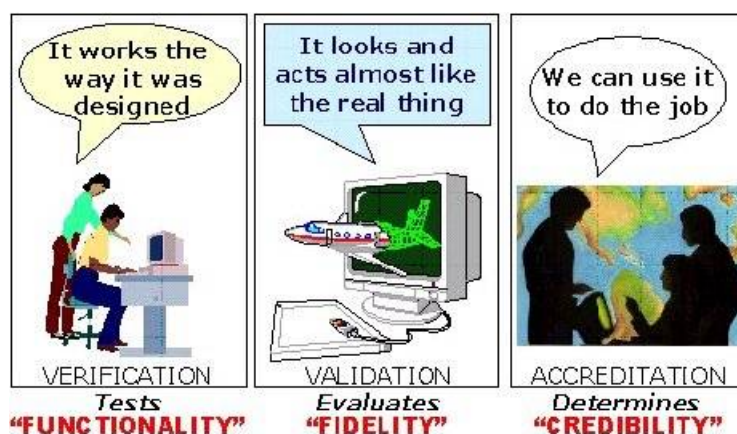


Figure 1. VV&A Defined

Prior to M&S usage, DON policy requires that the M&S complete the VV&A processes described in this handbook.

2 M&S PROCESS

The credibility of M&S is based on conscientious application of the process of Verification and Validation (V&V). A formal process of accreditation shall be employed to establish official approval of M&S as adequate for use in a particular application. The entire process is known as VV&A.

SECNAVINST 5200.38A, 28 February 2002

The quality of the VV&A process depends on the quality of the M&S process. The M&S process encompasses the entire M&S lifecycle from requirements definition through development, use, and support. The intent of this handbook is to provide VV&A guidance within the M&S process. VV&A complements the M&S process by gathering and examining its products to make an informed decision regarding the use of the M&S for a specific purpose. For successful VV&A, M&S development requires parallel VV&A activity during:

- M&S design
- M&S implementation
- M&S testing, and
- Analysis of (early) M&S results.

The M&S process comprises distinct, but intertwined and related program and project management processes and M&S development. Management should encourage close coordination between the VV&A and M&S processes. The relationship of these processes is shown in Figure 2. V&V acts upon the products of the M&S process while accreditation evaluates the products of the V&V process. Program and project management activities control the resources and quality of the processes all together.

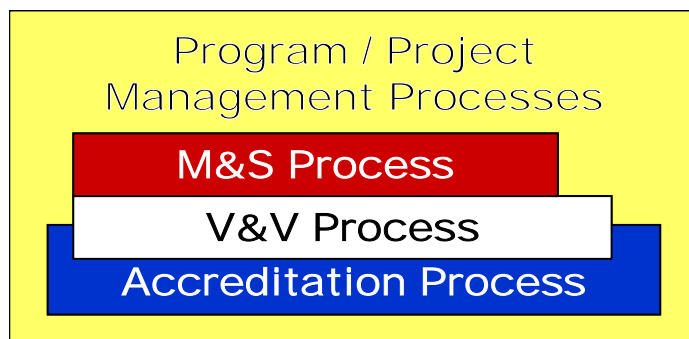


Figure 2. Process Relationship

VV&A is a tool that should be implemented early in the M&S process to help mitigate the risks of using the M&S. The conscientious implementation of VV&A provides credibility information so that the M&S can be used with an acceptable level of confidence, accuracy, and reliability. Additionally, VV&A helps to establish the quality of

the M&S, balance risks with resources, and support M&S reuse as well as to meet policy requirements.

Implementation controls require that V&V functions be performed throughout the M&S process to meet M&S requirements and that models and simulations represented are valid and realistic. V&V tasks are designed and planned to inspect the artifacts of the M&S process to determine if the user's acceptability criteria of the M&S are met. The M&S User's decision to apply the M&S results based upon a V&V inspection is called "accreditation."

The DON has developed general processes for verifying, validating, and accrediting models and simulations. The VV&A process can be tailored depending upon the intended use, acceptability criteria, resource constraints, and the type of M&S involved.

The intent of this section is to provide the relationship between the M&S and VV&A processes. The section provides a generic M&S process that is common to most M&S developments. Through discussion of the process, the key elements that are integral parts of VV&A are identified. Lastly; this section observes the artifacts developed throughout the M&S process.

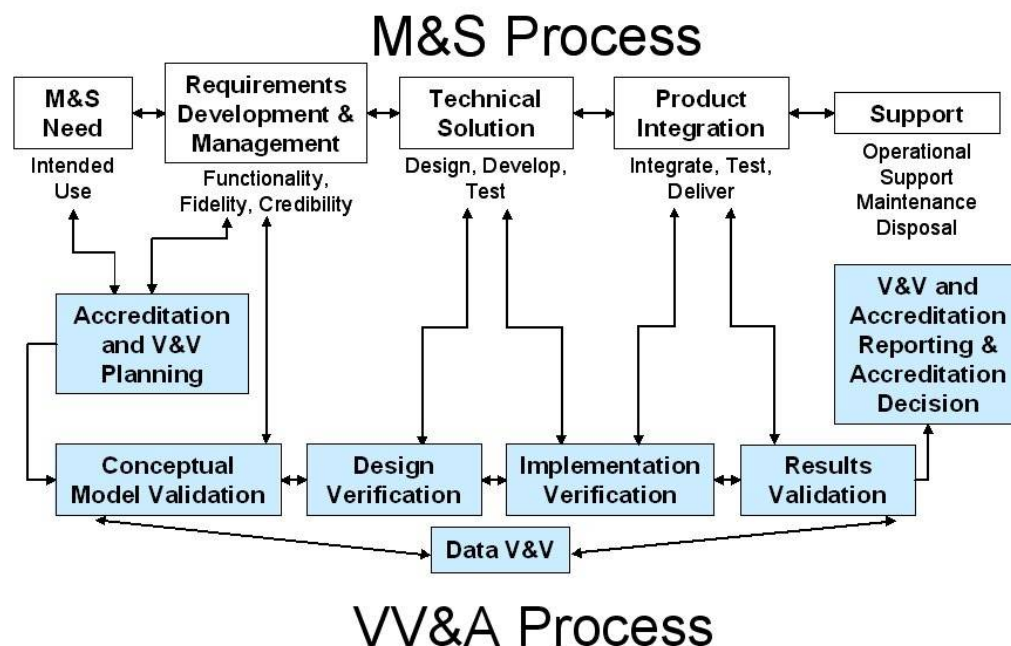


Figure 3. M&S and VV&A Relationships

The processes depicted in Figure 3 serve as foundations for any M&S or VV&A effort. Each effort must strike a balance between cost-effectiveness, responsiveness, and sufficiency to succeed. To maintain the balance between requirements and resource constraints, the VV&A process should be tailored to fit a set of three considerations: intended use, acceptability criteria, and type of M&S.

The M&S process is typically broken into phases, such as requirements definition, design, development, production and implementation, and support. The M&S lifecycle comprises the tasks, tools, standards, methods, and practices involved in fielding an M&S product. The quality of an M&S is usually determined by the quality of the processes used to define, develop, manage, and maintain it.

There is a relationship between Capability Maturity Model IntegrationSM (CMMI[®]) and the VV&A process. While the purpose of CMMI is to guide the improvement of an organization's processes and ability to manage the development, acquisition, and maintenance of products and services, the purpose of the VV&A process is to ensure the credibility and usability of M&S for a specific purpose. Integration of M&S processes with systems engineering and test processes creates an efficient continuum for establishing confidence in models and simulations. Too often today, errors that should have been found during development are being discovered at the end of the acquisition process, creating cost overruns and schedule delays. Early VV&A involvement together with a managed development process are required to meet program milestones, avoid costly delays, and gain the M&S User's confidence.

The primary purpose for conducting VV&A is to establish credibility and confidence in the use of the M&S results. Depending upon how early in the M&S development lifecycle that VV&A is initiated, the activities can identify potential problems or errors and help to mitigate risks. The M&S process is initiated with a need that in turn generates the requirements. This process includes conceptual modeling, design, development, integration, testing, and maintenance. The VV&A process should be planned and implemented as an integral part of the M&S process.

The following sections provide management processes, risk management, M&S work products, and high level discussions of each step in the M&S process. It is important to provide this understanding because the M&S process builds the foundation for the VV&A process.

2.1 M&S Management Processes

The M&S Support Plan is a management document that identifies how M&S will be used over the lifecycle of an acquisition program from concept and technology development to system disposal. It is a document that evolves as the system matures. Program Managers must plan for M&S throughout the acquisition lifecycle by identifying and funding required M&S resources. Management should plan and organize the development program in a manner that promotes close interaction between the M&S and VV&A processes.

2.1.1 Risk Management

Risks are future events with a probability of occurrence and a potential for loss. Risk is caused by a lack of information, control, or time. The purpose for risk management is to

identify potential problems before they occur, so that risk handling activities may be planned and invoked as needed across the lifecycle to mitigate adverse impacts on achieving objectives.

Risk management is used by managers to mitigate cost, schedule, and performance risks. When a manager uses a model or simulation in lieu of a real system or methodology to obtain data to support a decision, risks are incurred. The risks of using a model or simulation are mitigated through VV&A. The types of risk associated with M&S and VV&A include program/project management risks, V&V risks, and accreditation risks.

There are three primary layers of risk management involved when M&S is used. First, the program/project manager must manage the overall program/project risks; second, the authority accrediting the M&S must manage risks associated with the accreditation process; and third the model or simulation proponent must manage risks associated with the V&V processes. Although it is possible that the same person might play one, two, or all three roles, it is important to keep the specific responsibilities separate.

Risk management as related to VV&A is simply answering this question, “What is the risk of using a model compared to using the real world system or methodology?” To answer this question, two things must be understood: the level of risk in using the model relative to not using the model and the model’s capabilities and limitations. With the first, it is important to isolate the added risk of using the model from the risk of the decision itself. With the second, the VV&A process helps to provide the understanding of the capabilities and limitations.

The risks of using M&S are captured in the acceptability criteria. Weighting those risks (assigning impact and probability values to determine risk exposure) will help separate the essential acceptability criteria from those that could be tailored out or put on a watch list. Based upon the prioritized and weighted list of acceptability criteria, the V&V tasks can be identified and managed for risk similar to the acceptability criteria. By determining how to mitigate the accreditation risks through V&V, the overall risk of using the M&S can be better managed. A risk management process applied for VV&A has potential for helping managers understand VV&A and manage risk better. Risk should be documented as part of accreditation and V&V planning.

2.1.2 Typical Products of the M&S Process

Figure 4 provides examples of typical work products produced during the M&S process. Products that are specific to M&S include the intended use statement, requirements for use letter, M&S support plan, and the conceptual model description.

The other products shown in Figure 4 are more generic to program/project management and software and hardware development processes. These products represent typical documentation needed to design, develop, and deliver the final product. These documents include a variety of specifications, design descriptions, test descriptions,

plans, reports, manuals and configuration management (CM) artifacts. The documentation should tell the user how the M&S was developed, what it is, its functions, how to use it, and how to interpret the results. These products are gathered and examined during V&V to collect the evidence necessary to support a recommendation for accreditation.

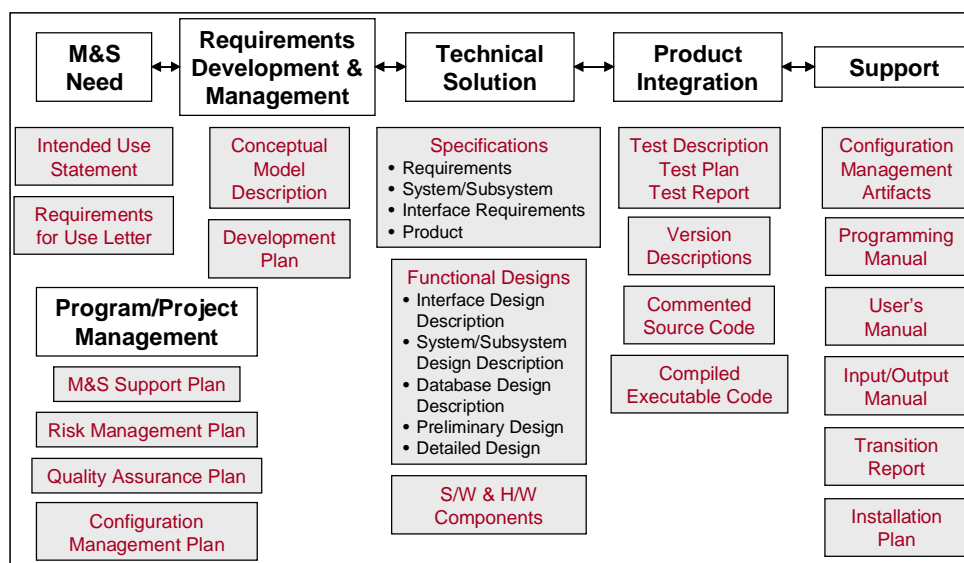
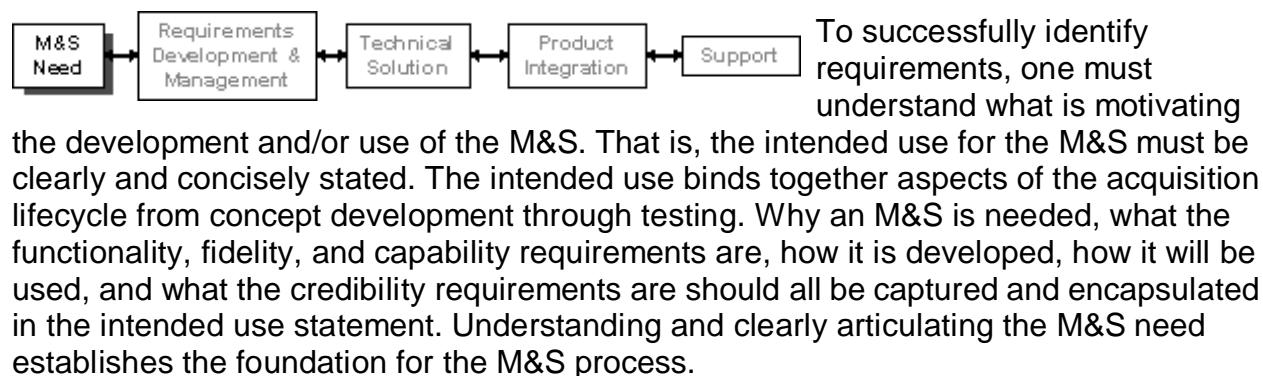
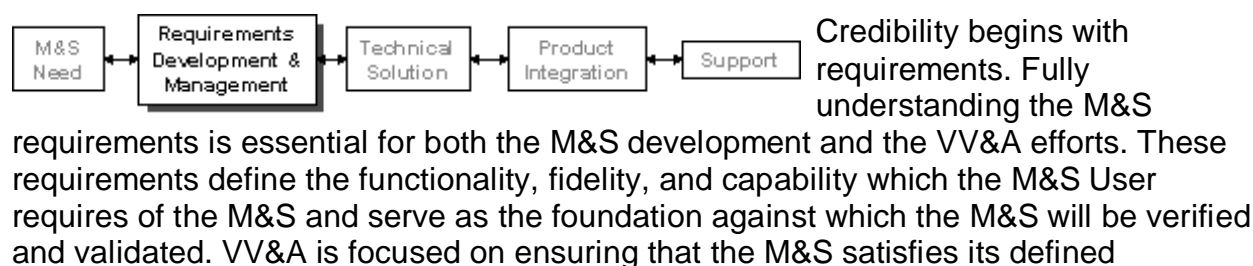


Figure 4. Typical Products of M&S Process

2.2 M&S Need



2.3 M&S Requirements Development and Management



requirements for use. As Figure 5 shows, an abundance of requirements documents and specifications should be examined to identify all necessary M&S requirements.

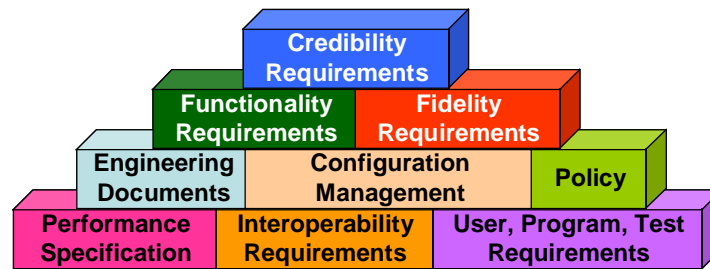


Figure 5. Sources of M&S Requirements

The M&S and VV&A combined efforts will identify which of the requirements documents in Figure 5 will be generated and/or will describe other requirements documents to be written. Larger scale M&S efforts may have requirements from several sources with descriptions showing the allocation and implementation of high-level requirements at lower levels. For smaller scale efforts, a single requirements specification may suffice. Once the requirements artifacts to be generated are established, then the extent of requirements verification can be established.

There are multiple levels of documents in which M&S requirements may be found. As an example, higher level requirements may be found in an Initial Capabilities Document or Capabilities Development/Production Documents for M&S used in acquisition programs. Once M&S performance requirements are defined from these higher level requirements, the technical M&S requirements may be derived in more detail. Lower level requirements also may be found in engineering standards or design documents. Whatever the source, each requirement must be thoroughly thought through as to how it applies to the use of the M&S, how it will be implemented in the M&S, and how it will be tested for validity.

M&S requirements are the requirements the user has for the specific intended use of the M&S results. M&S requirements are not necessarily the same as the specifications and requirements used to contract for the development of the model or simulation software or hardware. In the case of legacy M&S, there may be no conceptual model or original requirements documentation available. For new M&S, the requirements for the use of the M&S should be determined first and used to derive the specifications and requirements for the development of the M&S.

Cooperating in the development of the M&S requirements is a major activity. Programs are most successful when they provide as much specific detail as possible in these requirements. Requirements development is usually an iterative process. It is important for programs to identify a point in time when no new requirements changes will be accepted. Establishing a baseline for M&S requirements is necessary before entering the next phase, Technical Solution, which will be discussed in the following section.

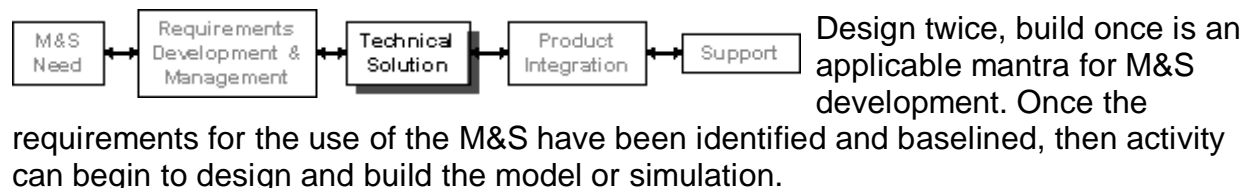
M&S requirements can be categorized into two broad classes: those that are essential to meet the M&S User's needs and those that are desirable. To effectively manage program resources, the essential and desirable requirements should be clearly identified and prioritized. According to the VV&A Recommended Practices Guide, good M&S requirements have three qualities:

1. Include requirements from the user, simulation, and problem domains
2. Be measurable (*and testable*)
3. Be traceable

Asking the right questions and capturing the right level of detailed requirements require a good deal of persistence and skill. This is not an activity that is performed only once. Understanding of the M&S User needs and refinement of M&S requirements must be iterated upon throughout the M&S process.

The completion of this activity will produce a sound set of M&S requirements. While this may seem simple, it is often the most tedious and difficult part of the process. M&S requirements are derived from the intended use of the M&S. Some sources of information that contribute to the development of M&S requirements include the Capabilities Development/Production Documents, Key Performance Parameters, System Performance Specification, Cost and Operational Effectiveness Analysis, Test and Evaluation Master Plan, Critical Technical Parameters, and M&S Support Plan. A set of M&S User-defined acceptability criteria, which are developed based upon the M&S requirements and intended use, will set boundaries for the V&V effort.

2.4 M&S Technical Solution



The first design step is to document the Conceptual Model description. The conceptual model is a taxonomy containing the assumptions, algorithms, and architecture that relates the elements of an M&S to one another. The Conceptual Model should address the simulation context, elements, and concept.

The Conceptual Model describes the data that will be used by, embedded in, or produced by the M&S. It is important at this point in the process to identify the data that will be required and to begin coordination with the data producers to gather and provide the data. It should be kept in mind that data producers, e.g., test ranges, operate on schedules and so the sooner the conceptual model data needs are provided to them the better the chances will be to collect that data. Additional instrumentation of ranges to collect validation data might add costs to the test being conducted. These are matters that must be worked out with the program far in advance of the actual test event.

The second step in the design process is to develop appropriate specifications that translate the conceptual description, which is documented in the conceptual model, to functional requirements in terms of technical performance and mission needs. Specifications may be needed for the system or subsystems, software and hardware requirements, or interface requirements.

The functional design is based on the specifications, which define the hardware and software that comprise the M&S. The functional design provides the developer's blueprint for the development of the M&S. The M&S functional design is most often documented by using graphical engineering diagrams that translate the specifications into design. Design features emphasize functionality, information flow, ordering of processes, and data accessibility.

Development artifacts are required to support VV&A and reusability. It is important that sufficient consideration be given in the contracting process to identify the artifacts that will be needed to support the VV&A effort and to contract for their delivery. Otherwise, the V&V effort will be required to reengineer the M&S application to create the evidence needed to support accreditation. Reengineering and recreation of development documentation is expensive and time consuming.

The final step in this process is to construct the technical solution, e.g., software modules and hardware components, that will comprise the model or simulation and to test each separately to ensure they are working properly, working as designed, and working as expected. In a fast-paced development environment, it is important to describe and baseline each component that will be integrated together in the next step. CM plays a major role here and will be discussed in a subsequent section.

2.5 M&S Product Integration



integration through the progressive assembly of modules, components, and subsystems. This should be accomplished in one stage or in incremental stages according to defined integration sequences and procedures. Once integrated, testing must be conducted to ensure that the algorithms and logic employed are correct and that the model or simulation satisfies the specified requirements. Test scenarios and test results should be recorded as those documents will be used to support implementation verification and results validation of the M&S system.

The results of integration testing may indicate that changes to the code and perhaps even the design are warranted. If changes are made, then retesting is required. Design and development documentation should be revised and updated accordingly based on the results of testing performed and the changes made. At the end of product integration, the M&S is delivered and ready for use.

2.6 M&S Support



M&S support is conducted throughout the M&S lifecycle and covers activities that

support development, deployment, and maintenance in the context of performing other processes, e.g., configuration management, quality assurance, training, technical support, operational support, and disposal.

CM is the key support element that binds together the various M&S process activities. Documentation is required throughout the M&S process and is critical for successful VV&A implementation activities. CM of that documentation enables traceability and provides the only way of understanding the original intended use, assumptions, limitations and capabilities.

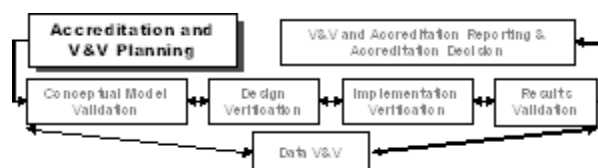
Demonstrated effective CM is required for any M&S undergoing accreditation. Version identification, tracking, and archiving are essential for any accreditation process. Source code, executable code, documentation, input data sources, hardware, and all other application materials are marked with the appropriate version number and archived. A CM plan documents all procedures, participants, and responsibilities in the configuration control of the M&S application. Once a specific version of hardware or software is accredited, it should not change configuration during the use period. Any changes that are made to the M&S must be tracked in the configuration control system.

3 VV&A PROCESS

The discussion in Section 2 provided the reader with a basic understanding of the steps that comprise the M&S process. The handbook now turns to a more detailed discussion of the VV&A process. The M&S and VV&A processes are intricately linked and the reader should refer back to Figure 3 often to visualize the connections. Having knowledge of the M&S process makes understanding how VV&A fits into the M&S process much easier. As stated earlier, V&V acts upon the work products of the M&S process and accreditation evaluates the work products of the V&V process. Whether the M&S being evaluated for use is a new development or legacy model or simulation, the work products of the M&S process are needed. In a new development, they should be contracted for, produced, delivered and provided for V&V evaluation as they are completed. If a legacy M&S is being assessed, the legacy documents must be gathered and provided for evaluation. Required information not available in legacy documents must be reengineered, produced and provided for the V&V.

The quality of the M&S process determines the efficiency and effectiveness of the VV&A process. Together these two processes provide checks and balances, ultimately deciding the credibility and usability of an M&S for a specific purpose. The VV&A process should be conducted continuously throughout the M&S process whether it is a new development or a legacy M&S undergoing modification. The VV&A process is tailorable to the specific organization's requirements, type of M&S, and importance of the use for which it is undergoing VV&A. Information obtained from the VV&A process early in the M&S process can assist in addressing errors or problems in the development of the M&S.

3.1 VV&A Planning



Planning activities include documenting the intended use, identifying requirements for use of the M&S results, documenting acceptability criteria, and establishing the V&V methodology for addressing the

acceptability criteria.

3.1.1 Accreditation Planning

Accreditation addresses both new and legacy M&S in the full spectrum of M&S classes (live, virtual, and constructive) across functional areas and implementations (unitary, distributed) in a coherent and formal way so that synergism among VV&A efforts can occur. Accreditation is specific for a particular intended use.

Acceptability criteria are the set of standards that a particular M&S must meet to be accredited for a specific purpose. The criteria address each M&S requirement and describe how each requirement will be evaluated. Acceptability criteria determine the capabilities desired in the M&S that warrant accreditation. It is recommended that a

documented version of the acceptability criteria be provided prior to the initiation of V&V planning. Acceptability criteria are the qualitative or quantitative measures and metrics that an M&S must meet to be accredited for a specific purpose. Acceptability criteria provide a means of evaluating the M&S from the perspective of the M&S requirements. They serve as the foundation against which the simulation will be verified and validated. Acceptability criteria are:

- Qualitative or quantitative measures of merit that some aspect of the required M&S performance is satisfactory.
- Some level of demonstrated M&S performance, for example, demonstrating that ship propulsion system model outputs equal the expected levels of power.
- The accomplishment of a process at some level of efficiency, for example, simulation of an aircraft's flight control response in real-time.

The acceptability criteria for each of the M&S requirements can be categorized into essential and desired levels of performance, functionality, fidelity, or credibility. These, too, should be prioritized for effective resource management. Factors affecting the priority include, but are not limited to, magnitude of the impact to the M&S User if output results are in error, degree of associated cost, or the degree of difficulty in verifying or validating a particular aspect of the M&S. Acceptability criteria should be reviewed throughout the development process to ensure they remain appropriate and sufficient. Acceptability criteria are developed, derived, and defined through an iterative review and interview process possibly involving all the key VV&A players, which are described in Section 5, VV&A Roles and Responsibilities.

3.1.2 V&V Planning

Thorough accreditation planning contributes significantly to V&V planning, while effective V&V planning can help to ensure the success of V&V task execution and report generation. Throughout this handbook, the need for V&V to be fully integrated into the larger context of M&S planning, development, management, and utilization is stressed. The V&V processes must be formalized such that documented results of activities are readily accessible for use by subsequent M&S efforts, which supports and promotes the concept of reusability.

V&V can be decomposed into five documented functional events. These include data V&V, conceptual model validation, design verification, implementation verification, and results validation. V&V planning identifies tasks that address the acceptability criteria, M&S requirements, resources, and timelines.

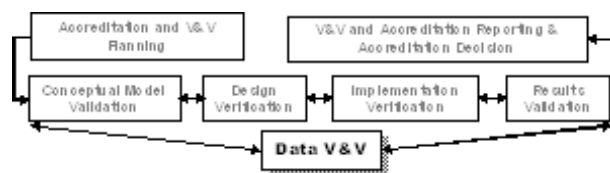
Formal guidance and requirements are collected and reviewed to determine the constraints under which the M&S V&V, data V&V, and accreditation efforts will operate. Appropriate evaluation techniques and measures are identified. Necessary tools and resources are selected and specific activities scheduled. Tailoring the selection of V&V techniques and processes, based on requirements and resource availability, is done as part of VV&A planning.

For new M&S, the V&V activities ensure the M&S requirements are properly implemented throughout the M&S development lifecycle. For legacy M&S, the V&V activities ensure the M&S implementation is consistent with its documented capabilities and that the M&S requirements can be mapped into the documented M&S capabilities.

A few suggested questions to ask when initiating V&V planning are as follows:

- How will each acceptability criterion be addressed?
- Is there a requirements traceability matrix?
- What are the important inputs to and expected outputs of the M&S? What parts of the M&S are most responsible for the results? How will credibility of the underlying algorithms and associated data be determined?
- Will it be necessary to obtain Subject Matter Expert (SME) review?
- Does the M&S have adequate and current documentation? If not, will reengineering the M&S to produce the needed evidence be worth the cost?
- Is there a test plan and are there test procedures that describe how the M&S was tested? Are the M&S requirements sufficiently described in test plan?
- Was configuration management applied to control versions and to identify what components make up the M&S?
- Are there sufficient time and resources to complete the needed tasks and provide credible results? What will be the impact if some of the V&V tasks cannot be supported?

3.2 Data V&V



Data are critical to the successful application of most M&S in use today. Data used in M&S applications affect the M&S accuracy and credibility of results. Such data often must be interpreted and

translated for use in a particular M&S application. Data V&V examines the data used to develop and run the M&S. Data credibility is dependent not only on how the data are produced and maintained, but on how the data are transformed and used in the M&S. Data verification is conducted to ensure that the data selected are the most appropriate for the application and are properly prepared or transformed for use in the M&S. Data validation is conducted to ensure that the data accurately represent aspects of the real world to be simulated.

Data that require V&V fall into five categories: data needed to (1) verify M&S requirements; (2) build the conceptual model; (3) validate the M&S; (4) perform experiments; and (5) run combat support M&S decision aids. Five types of data are examined during data V&V activities. Brief descriptions of each type of data appear in Table 1. It is important that the data used to develop and validate M&S are the right data to use. Data V&V activities should be integrated along with the other V&V tasks to ensure that data are used for the appropriate purpose.

Table 1. Data Types

Data Type	Description
Reference	Descriptive information (metadata) including administrative, descriptive, and quality
Hard-wired	Data values implemented in code
Instance	Input and output data
Validation	Real world facts
Exchange	Data exchanged across a federation or distributed simulation

By stepping through the typical data V&V activities shown in Figure 6 in parallel with V&V implementation activities, the V&V Agent can ensure that the proper data was identified, obtained, and used properly in the M&S.

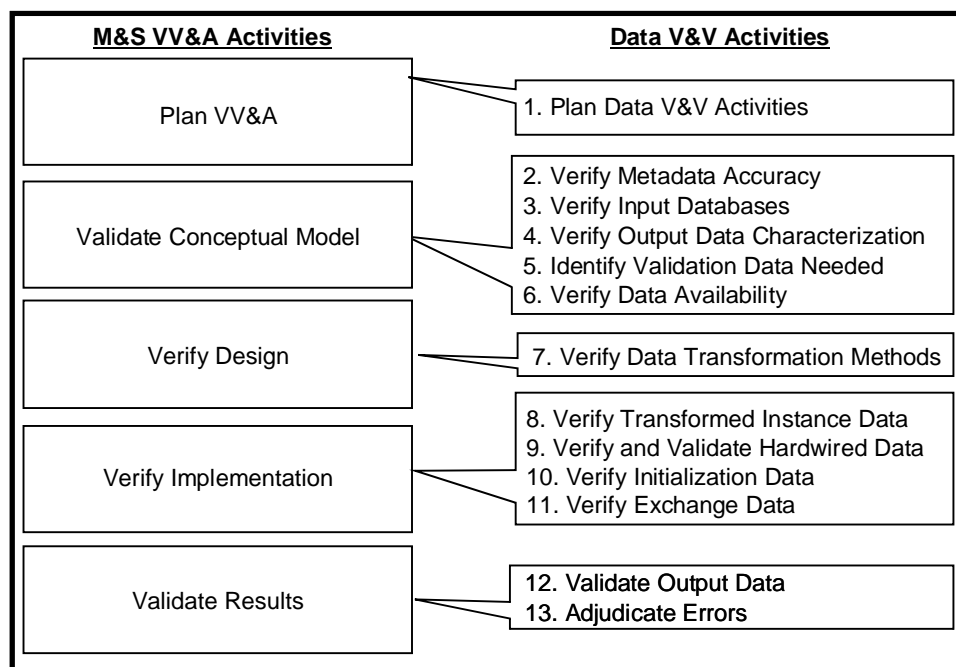


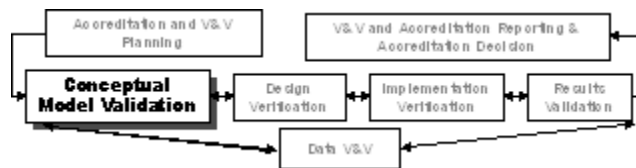
Figure 6. Data V&V Activities

Department of Defense (DoD) M&S Executive Agents (MSEAs) are designated by the Under Secretary of Defense for Acquisition, Technology, and Logistics to serve as domain SMEs for the M&S community. Their roles are to provide timely and authoritative representations of the natural environment and systems, and to establish V&V procedures for common and general-use M&S representations and their data. The DoD MSEAs are sources of valid M&S data.

3.3 V&V Implementation

There are five major V&V activities that should be conducted to some degree during V&V implementation, as shown above in Section 2, Figure 3. These activities include data V&V (discussed above in Section 3.2), conceptual model validation, design verification, implementation verification, and results validation. At each step of the V&V Process, artifacts produced during M&S development are examined.

3.3.1 Conceptual Model Validation



The conceptual model serves as a bridge between the defined requirements and the M&S design, providing the developer's interpretation of the requirements to which the model or

simulation will be built. The conceptual model is the documented theoretical approach to the design of the M&S. The conceptual model takes into consideration the M&S requirements, the intended use, data requirements, and risks associated with producing and using the M&S. The development of the conceptual model is the important first step in the M&S process. The conceptual model describes what the M&S is expected to do, to be, and what data and other elements are needed for a successful outcome.

The objective of performing conceptual model validation is to demonstrate that the M&S functional elements accurately and completely represent the M&S requirements, and to identify where assumptions, limitations, or architectural structure impact the intended M&S use.

Results of the conceptual model validation are documented in the V&V Report. The report explains why (or why not) the assumptions, algorithms, modeling concepts, data, and architecture together are expected to provide an acceptable representation for the intended application of the M&S. Any interactions expected with other simulations, i.e., in a federation, also must be examined and documented in the conceptual model validation portion of the V&V Report. A total integrated vision is an important element in conceptual model validation.

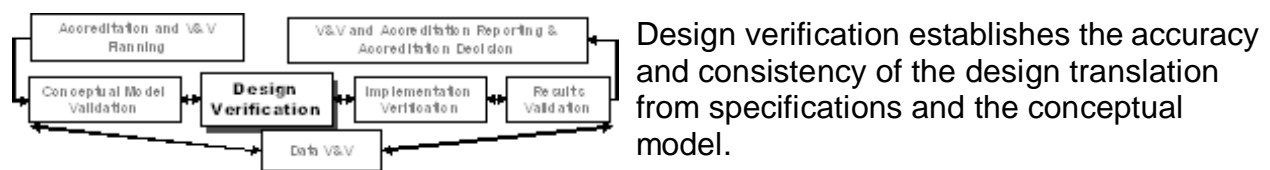
Conceptual model validation should occur before further M&S development, to avoid the potential pitfall of inaccurately representing the system and not meeting the proposed M&S requirements. Errors caught at this early stage of development are far easier and less expensive to fix than errors detected and corrected later.

For new M&S, conceptual model validation leads to early detection and correction of errors. Uncovering and resolving discrepancies early in the M&S process can result in substantial cost avoidance, as well as increasing M&S User satisfaction with the final M&S application.

Often with legacy M&S, the conceptual model has not been formally documented. In this case, development documentation, past usage history, and past VV&A documents can be reviewed to determine whether or not validation of the conceptual model can be tailored out of the V&V Plan. For legacy M&S, conceptual model validation identifies any discrepancies between the existing M&S representation and the new M&S requirements. This allows the M&S User to plan and budget for necessary changes or enhancements to the M&S to support the intended use.

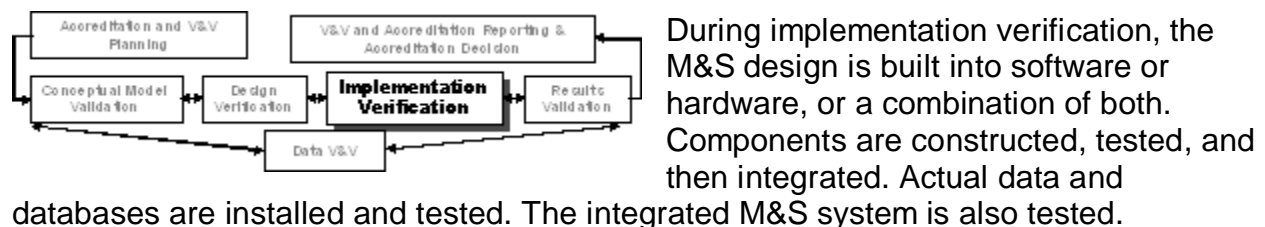
Validation of the conceptual model is the judgment process that provides assurance to move into the next stage of development.

3.3.2 Design Verification



Design verification examines the specifications and functional designs that define the performance requirements, hardware, and software that will comprise the M&S. It ensures that all the features, functions, behaviors, algorithms, and interactions defined in the conceptual model are correctly, completely, and consistently included in the specifications and design documentation. Specifications and functional designs are verified against the validated conceptual model to ensure they accurately reflect the concept, address the M&S requirements, and satisfy the acceptability criteria for accreditation.

3.3.3 Implementation Verification



Implementation verification is the formal (i.e., documented) test and review process that determines the M&S accurately represents the functional design and has traceability to the conceptual model and the M&S requirements. Implementation verification demonstrates that the integrated M&S accurately represents the design and the M&S requirements.

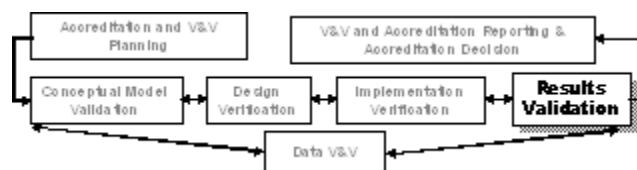
M&S implementation verification looks at timing and protocol constraints on M&S processing. It examines how the M&S system accommodates unanticipated, or out of specification, inputs. It examines how well the components were developed in accordance with contemporary engineering and DoD standards of structure, testing,

quality assurance, and documentation. M&S implementation verification examines how well components comply with the associated specifications.

It may be possible to leverage the results of testing that was conducted as part of the development effort if test plans and test reports are available for inspection. Specific M&S implementation verification tasks that were adequately addressed during development or maintenance activities need not be duplicated.

The tasks associated with M&S implementation verification are designed to establish how well the M&S system represents the design, system specification, and conceptual model. The end product of M&S implementation is the actual M&S application with all uncovered defects and their impacts documented within the V&V Report.

3.3.4 Results Validation



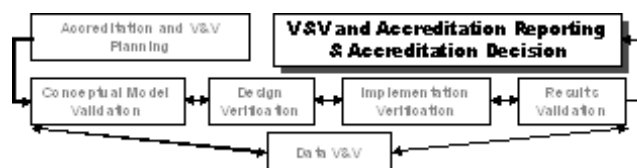
Results validation is the formal (i.e., documented) test and review process that compares the responses of the M&S with known or expected behaviors, in order to determine that the M&S

responses are sufficiently accurate. Results validation is the rigorous comparison of M&S performance with real world phenomena from the perspective of the intended use. Results validation compares the M&S results to some authoritative reference data that defines what the expected results should be.

Results validation is conducted to determine the extent to which the M&S addresses the requirements for use, to identify how realistic the outputs are, and to document how well the simulation fits the intended use.

When real-world empirical data are not available, SMEs are relied upon to provide assessments as to the credibility of the M&S results. In addition, M&S results can be compared, or benchmarked, against other similar validated M&S results when no other referent resources are available. There are many methods of data comparison and the selection of a method is a function of the type of data being compared.

3.4 Accreditation Implementation



Several activities comprise accreditation implementation. Upon receipt of the accreditation package and request to accredit, an assessment of all materials in the accreditation package and the

M&S itself is begun. Following completion of the assessment, an Accreditation Report is written containing the recommendation for accreditation. Based upon the recommendations made in the Accreditation Report, the accreditation decision is made, documented, and disseminated. The activities which are conducted during accreditation

implementation are discussed further in the following sections.

3.4.1 Accreditation Assessment

Depending upon how early in the M&S and V&V processes that accreditation activities began, the depth of the accreditation assessment may simply be based upon the careful review of information contained in the accreditation package. If a thorough understanding of the critical issues was gained through participation in the V&V process, this assessment can be relatively simple and may be less detailed. The documents contained in the accreditation package, with emphasis on the V&V Report, are reviewed and assessed to determine if the M&S is credible and usable for the intended use. Reviewers should have the expertise to make informed judgments about the M&S capabilities and limitations. The documents are evaluated according to the methodology specified within the Accreditation Plan. The critical M&S qualities are measured against the acceptability criteria and the M&S requirements. Discrepancies are identified, along with recommendations as to any workaround solutions, remaining risks, and limitations to use.

Based upon the thoroughness of the supporting documents, additional testing might be required, which can stop the assessment process entirely until the needed data are provided. This is a major reason why early involvement in the M&S process is necessary and that adequate V&V planning is conducted and implementation funds are allocated.

Effective communications are important to successful accreditation. The ability to condense and highlight relevant information from the mounds of detailed evidence collected and contained within the accreditation package is a challenging, but critical part of the task. It is important to remember that insights will generally be qualitative in nature even though the methods they derive from are quantitative.

3.4.2 Accreditation Decision

Based on the Accreditation Report and a recommendation for accreditation, a decision is made and documented in an accreditation decision letter. Several decision options are available to the decision-maker:

Full Accreditation	M&S produces results that are sufficiently credible to support the application
Limited/Conditional Accreditation	Constraints are placed on how the simulation can be used based upon the evidence assessed, the need for additional information to be provided, or modifications required to the M&S
Non-accreditation	Results of the assessment show that the simulation is not fit to support the application

3.4.3 Accrediting Reused M&S

Reuse encompasses not only the use of a model or simulation itself, or components of the model or simulation, but also leveraging the VV&A artifacts (documentation, test results, and reports). Accreditation by definition is for a specific intended use. Accreditation for the intended use determines whether the M&S can be applied for a unique purpose. Accreditation for reuse then must focus on the new intended use of the M&S. Accrediting for a new intended use, or re-accreditation, requires that a new accreditation decision be made. If the M&S is to be reused, then the M&S must be accredited for the new intended use.

Reusing previously accredited simulations will require some level of VV&A. If the intended use is similar, then little effort may be required. If the intended use is different, then significant V&V effort might be necessary. If the use is the same, but the system modeled has changed, then the M&S must be accredited to determine whether it still represents the modeled system and is the right M&S for the intended use.

If the M&S has changed and the intended use is the same or similar to the one for which it was originally accredited, then the changes to the M&S must be verified and validated to determine the impact, if any, to the intended use. The changes made to a previously accredited M&S should have been kept under configuration control and documented, making the V&V easier to do.

In any case, the V&V accomplished for a prior accreditation should be reexamined and reused, if applicable, when building an accreditation package for the new intended use.

4 VV&A DOCUMENTATION

VV&A planning and implementation activities must be documented for all DON M&S. The minimum required VV&A documents include the Accreditation Plan, V&V Plan, V&V Report, Accreditation Report, and Accreditation Decision Letter. A signed letter documenting the M&S requirements and the intended use is also recommended. The Accreditation Package is the collection of all sources of information used to document the evidence in the V&V Report. Each document will be discussed in more detail in the following sections.

Documentation from the developer describing the M&S and its capabilities (for legacy M&S) or planned capabilities (for new M&S) is also needed. For new M&S, documents that should be available in the VV&A planning stage include the requirements specification and the conceptual model. As the development continues, various other specifications, design documents, related test documentation, and manuals should be made available for V&V inspection. For legacy M&S, the types of development documents expected would include specifications, conceptual model, designs, test reports, M&S support plan, user's manual, programmer's manual or notes, development history, use history, and previous VV&A information. Additionally, all M&S undergoing accreditation must be under configuration control. The configuration management plan and other artifacts of the configuration control process are required to support the accreditation assessment.

4.1 Planning Documents

There are two key planning documents produced during the VV&A process. The first is the Accreditation Plan and the second is the V&V Plan. Both are described in the paragraphs below.

The documents supporting the various types of M&S, i.e., new development, legacy, stand-alone, distributed simulation, federation, etc., should contain the same types of information. However, the level of detail might be different based upon the type of M&S. For instance, a description based upon a legacy M&S, one that had no documented conceptual model or design information available, may be less complete than the description of a new M&S with a conceptual model document upon which to base the M&S description. Each plan may be tailored based upon such things as the intended use, scope of the VV&A effort, type of M&S, an organization's own documentation requirements, resource constraints, etc.

Some information is common to both plans. Those common elements include the statement of the intended use; description of the M&S, including capabilities, assumptions, and limitations; pertinent background information; and identification of key VV&A players and organizations. In addition, each plan should include a schedule, estimated costs, and an explanation of the methodology that will be employed to accomplish the accreditation or V&V tasks. Information that is specific to each individual plan is discussed below.

The Accreditation Plan is the first document produced in the VV&A process. The plan documents the requirements for the use of the M&S, generally referred to as M&S requirements. With a clear understanding of the M&S requirements, the acceptability criteria can be defined. The acceptability criteria are the set of standards that an M&S must meet to be accredited for a specific purpose. Additionally, the measures and metrics that will be used to judge whether or not the acceptability criteria have been met, commonly known as measures of effectiveness and measures of performance, are documented in the Accreditation Plan. Together with the common information mentioned above, this information provides the basis for V&V planning to take place.

The V&V Plan is the second document produced in the VV&A process and contains the common information from the Accreditation Plan. The V&V Plan should ensure that, given inevitable cost and schedule constraints, the V&V efforts will address the most important questions pertaining to the suitability of the M&S for a specific use. The plan should interpret the acceptability criteria and refine the M&S requirements to identify which V&V tasks are necessary to implement in order to produce the information needed to support accreditation of the M&S for the intended use. The plan should discuss each technique to be used, state why that technique is most appropriate, and include the measures and metrics that will be used to report and analyze the results. Additionally, the data needed to perform results validation and the methods for obtaining the data should be identified in the plan. The plan should address the potential risks involved with each task, plans for mitigating the risks, and risks involved should individual tasks be tailored out, i.e., what uncertainties will exist should a V&V task be unfunded. The V&V Plan also addresses personnel, funding, and schedule by prioritizing the inspection of the highest-risk areas of the M&S.

A V&V Plan for an M&S being modified for use may also include information about the development history, a summary of past application(s), and any past V&V status. A V&V Plan for legacy M&S with little documentation will include past development histories, past applications, past V&V status, and reengineering issues.

The accreditation and V&V plans are living documents thus allowing the flexibility for adjustment and refinement as each process progresses.

4.2 Implementation Documents

Once the accreditation and V&V plans are approved, the next steps are to implement each of the plans and report the findings. There are three key documents produced in the implementation phase of the VV&A process: the V&V Report, Accreditation Report, and Accreditation Decision Letter. The V&V Report documents the evidence supporting the functionality and fidelity of the M&S to satisfy the acceptability criteria and M&S requirements. The Accreditation Report summarizes the assessment of the V&V evidence and documents the credibility and usability of the M&S for the specific use. The Accreditation Decision Letter specifies the uses for which the M&S is accredited or limitations of the M&S that are attached to the accreditation decision.

The third document produced in the VV&A process is the V&V Report, which records the results of the V&V activities. This report is the only recorded evidence that V&V was ever conducted and is the single most important document produced to support an accreditation decision. It captures the V&V findings; the assumptions, capabilities, and limitations of the M&S; the conclusions drawn and any recommendations made. The V&V Report should trace the findings back to the acceptability criteria they satisfy as well as identify any criteria that were not addressed by the V&V.

The V&V Report for legacy M&S may draw heavily on documents previously produced for the legacy M&S during design, development, testing, or use. These documents may not necessarily have the words "verification", "validation", or "accreditation" in the document title; however, they may contain information useful for verifying or validating an M&S and together form a body of evidence that support an accreditation decision. Therefore, this legacy evidence should be gathered and the pertinent information should be synthesized and summarized in the V&V Report. The summary should highlight the M&S capabilities, limitations, and constraints in relation to the intended use.

Once the V&V Report is finalized and approved for distribution, it is incorporated with other supporting documents into an Accreditation Package. The objective of the accreditation package is to provide enough documented evidence about key aspects of an M&S that a clear judgment regarding the adequacy of the M&S to support the intended use can be made. The documentation provided should constitute sufficient supporting evidence of the suitability of the M&S for the intended use. Exactly how much evidence and what specific types of evidence are gathered are unique to each accreditation sought. It depends on the nature of application and how critical it is to establish the credibility of the M&S, the existence of available M&S documentation, and the resources available to collect the evidence. The development of this package should be integrated into the M&S lifecycle as early as practical.

The fourth document produced in the VV&A process is the Accreditation Report. The total output of the technical review of the accreditation package is documented in the Accreditation Report. The Accreditation Report documents the findings of the accreditation assessment with regard to the acceptability criteria. Applicable findings from the V&V Report are highlighted in the Accreditation Report. The Accreditation Report should provide the necessary insights so that an informed decision regarding the use of the M&S can be made. The Accreditation Report contains the recommendation for accreditation.

The fifth and final document in the VV&A process is the Accreditation Decision Letter, which documents the accreditation decision. The decision letter is the only proof that formal VV&A processes were conducted and an informed decision was made on the credibility and usability of the M&S for a specific intended use. The decision could be based entirely upon the recommendation made in the Accreditation Report. If additional questions arise because the supporting documentation is lacking in some way, the Accreditation Letter documents the questions. The Accreditation Decision Letter must

clearly specify the M&S name, version, version date, and any operational limitations that are attached to the accreditation decision.

The V&V and accreditation reports should focus on documenting only the information needed to satisfy the M&S requirements and acceptability criteria for the intended use of the M&S. To do otherwise could waste scarce resources.

4.3 VV&A Documentation Tool

The concept for the VV&A Documentation Tool (VDT) and information contained in the tool are based on the guidance provided in this handbook. NAVMSMO sponsored the development of the VDT to automate the VV&A process and to guide users in the production of consistent and meaningful VV&A documents.

The VDT assists users in planning, implementing, and documenting VV&A activities. The tool provides the behind-the-scenes organizational structure between three key aspects of the process: Plan, Implement (the plan), and Report. Planning is divided into accreditation planning and V&V planning. As the plans are implemented, the results from the analyses of the activities conducted are captured in the VDT to be output in report format. Reporting is divided into V&V reporting and accreditation reporting.

The VV&A Documentation Tool guides the user through the steps of the VV&A process. The tool is designed to aid those involved in the Navy's M&S efforts in collecting, organizing, and documenting information pertaining to the VV&A of models and simulations.

- Go to: <http://navmsmo.hq.navy.mil>
- Click on: VV&A
- Click on: VV&A Documentation Tool
- Follow the instructions to register.

For general information about the VV&A Documentation Tool, contact NAVMSMO at vva@navmsmo.hq.navy.mil. For technical questions, contact vvadoc@navy.mil.

5 VV&A ROLES AND RESPONSIBILITIES

DON is charged in DoDI 5000.61 to designate, delegate authority to, and assign responsibilities for key players in the VV&A process and does so in SECNAVINSTs 5200.38A and 5200.40A. It is important then to understand who these key VV&A players are and the role each fulfills in the VV&A process.

While reading the information presented here, it should be kept in mind that an individual, group, or organization might fill more than one role in the VV&A process. The roles and responsibilities are the same no matter the size of an organization or the type of M&S; but how they are implemented may differ from organization to organization.

For instance, in an acquisition program where M&S will be used to supplement operational testing, the Accreditation Authority and the M&S Proponent are always different organizations. In the Navy, the Accreditation Authority is the Commander, Operational Test and Evaluation Force (COMOPTEVFOR), the Navy's independent operational test agency. COMOPTEVFOR typically designates a subordinate as Accreditation Agent most often with contractor support funded by the acquisition Program Office. The Program Office previously served as the Accreditation Authority for the M&S when it was used for earlier developmental testing. The M&S Proponent is the Program Office and may hire a government laboratory or contractor as V&V Agent. The M&S Developer may be a contractor, a government laboratory, etc. A second example would be a Naval Operations (OPNAV) organization with the need to accredit models used to produce budget estimates. In this case, the Accreditation Authority, M&S Proponent, and M&S Developer may all be part of the same organization. The Accreditation Authority might designate an Accreditation Agent within the organization or hire a contractor. The M&S Proponent may handle the responsibilities of the V&V Agent with organizational support. A third example may be of a large scale federation comprised of several simulations from differing organizations. The structure to VV&A this federation may be massive and comprise multiples of each role. In each example above, it is impossible to determine what the VV&A team should be until the needs of the M&S User and Accreditation Authority are clear. Once known, the roles and responsibilities should be tailored to meet those needs.

Definitions are provided below for simple clarification.

Accreditation Agent: *The individual, group, or organization designated by the Accreditation Authority to conduct an accreditation assessment for an M&S.*

Accreditation Authority: *The organization/individual who approves the use of an M&S for a particular application. The Accreditation Authority represents the M&S User's interests. The Accreditation Authority is a Government entity.*

DoD Modeling and Simulation Executive Agent (MSEA). *The DoD-assigned organization with responsibility and authority for development and maintenance of a*

specific area of M&S application, including relevant standards and databases used by or common to many M&S capabilities.

M&S Developer: The individual, group or organization responsible for developing or modifying a simulation in accordance with a set of design requirements and specifications.

M&S Proponent: The organization that has primary responsibility for M&S planning and management that includes development, verification and validation, configuration management, maintenance, use of an M&S, and others as appropriate. The M&S Proponent is a Government entity.

M&S User: The individual, group, or organization that uses the results or products from a specific application of an M&S. The M&S User is a Government entity.

Subject Matter Expert: An individual who, by virtue of education, training, or experience, has expertise in a particular technical or operational discipline, system, or process.

Verification and Validation (V&V) Agent: The individual, group, or organization designated by the M&S Proponent to verify and validate an M&S.

The relationships of the roles defined above to one another are depicted in Figure 7.

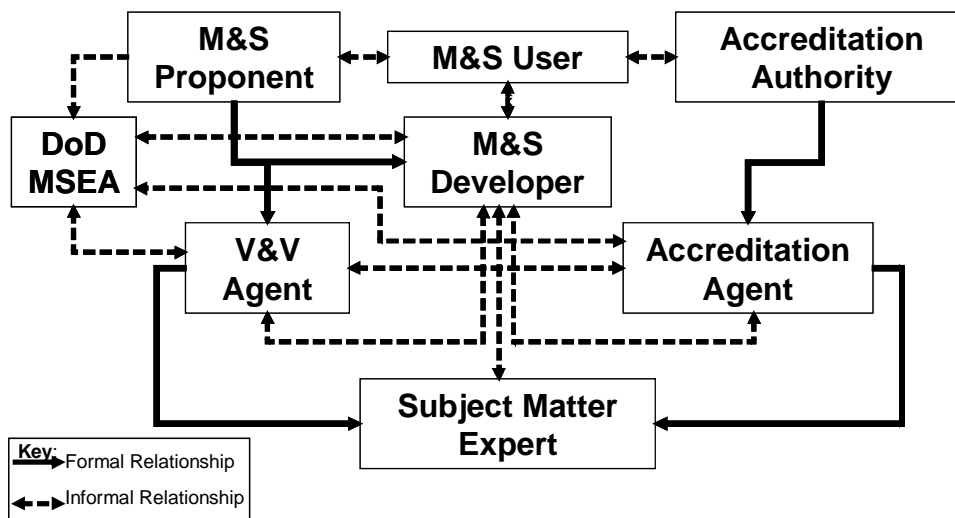


Figure 7. Relationships of Key VV&A Players

The M&S User works together with the M&S Proponent and Accreditation Authority to ensure the M&S requirements are defined and understood. The M&S Proponent will establish formal relationships with the M&S Developer and V&V Agent. Likewise, the Accreditation Authority will have a formal relationship with the Accreditation Agent. Both the V&V Agent and Accreditation Agent may establish formal relationships with SMEs

who will contribute to the respective activity based upon their academic, technical, or operational background. The M&S Developer provides technical expertise regarding simulation capabilities to the other key VV&A players.

Table 2 identifies seven key VV&A roles and their responsibilities as a function of the VV&A process tasks.

Table 2. VV&A Roles and Responsibilities

Task	M&S User	Accred. Authority	Accred. Agent	M&S Proponent	V&V Agent	M&S Developer	SME
Define M&S Requirements	Approve/ Assist	Monitor/ Review	Lead	Review	Assist	Assist	Assist
Acceptability Criteria	Assist	Approve	Lead	Review	Assist	Assist	Assist
Accreditation Plan	Review	Approve	Lead	Monitor	Review	Review	Assist
V&V Plan	Review	Monitor	Review	Approve	Lead	Review	Assist
V&V Implementation	Review	Monitor	Monitor	Approve	Lead	Assist	Assist
V&V Data	Review	Monitor	Monitor	Approve	Lead	Assist	Assist
V&V Report	Review	Monitor	Monitor	Approve	Perform		Assist
Accreditation Package				Approve	Perform	Assist	
Accreditation Assessment	Monitor	Monitor	Lead				Assist
Accreditation Report	Review	Approve	Perform				Assist
Accreditation Decision	Review	Perform	Assist				
VV&A Archive & M&S Catalog	Perform	Perform		Perform			
Accredit For Reuse	Review	Approve	Lead	Assist	Assist	Assist	Assist
Accreditation Status	Perform						

Responsibilities are divided into six categories: lead, perform, assist, monitor, review, and approve. The definitions of each of these responsibilities are provided below.

- Lead – Leads the task; normally involves active participation from others.
- Perform – Does the task; normally requires little active participation from others.
- Assist – Participates actively in the task (e.g., conducts tests, provides information).
- Monitor – Oversees the task but does not normally participate.
- Review - Reviews results of the task and provides recommendations.
- Approve – Decides when the task is satisfactorily completed and another can begin; determines what task should be pursued next.

When establishing a VV&A team, some thought should be given to how the team members will communicate with one another. All VV&A players must communicate, coordinate, and cooperate both formally and informally throughout the VV&A process for it to be successful. Communication should begin as early as possible and be based upon the level of the effort.

6 GLOSSARY

ACCEPTABILITY CRITERIA. A set of standards that an M&S must meet to be accredited for a specific purpose.

ACCREDITATION. The official certification that an M&S and its associated data are acceptable for use for a specific purpose.

ACCREDITATION AGENT. The individual, group, or organization designated by the Accreditation Authority to conduct an accreditation assessment for an M&S.

ACCREDITATION AUTHORITY. The organization/ individual who approves the use of an M&S for a particular application.

CREDIBILITY. The quality of being believable or trustworthy.

CONCEPTUAL MODEL. The developer's description of what the model or simulation will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the M&S User's requirements. A collection of assumptions, algorithms, relationships, and data that describe a developer's concept about the simulation.

DATA. A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means. Assumed, given, measured, or otherwise determined facts or propositions used to draw a conclusion or make a decision.

DATA VERIFICATION AND VALIDATION. The process of verifying the internal consistency and correctness of data and validating that it represents real world entities appropriate for its intended purpose or an expected range of purposes.

INTENDED USE. The application of a model or simulation for a specific purpose.

LEGACY M&S. Any M&S that was developed either in the past or for a different purpose.

M&S DEVELOPER. The individual, group or organization responsible for developing or modifying a simulation in accordance with a set of design requirements and specifications.

M&S EXECUTIVE AGENT. The DoD-assigned organization with the responsibility and authority for the development and maintenance of a specific area of M&S application, including relevant standards and databases used by or common to many M&S capabilities. M&S Executive Agents have been designated for Terrain, Atmospheric and Space, Intelligence, and Oceanographic Environments.

M&S PROPONENT. The organization that has primary responsibility for M&S planning and management that includes development, verification and validation, configuration management, maintenance, use of an M&S, and others as appropriate.

M&S LIFECYCLE. The period of time beginning when an M&S product is conceived and ending when the product is no longer available for use. The M&S lifecycle is typically broken into phases, such as requirements definition, design, development, test, and operation and maintenance.

M&S REQUIREMENTS. The collection of requirements that an M&S must meet to serve a particular purpose. M&S requirements include problem, M&S User, and simulation domain requirements.

M&S USER. The individual, group, or organization that uses the results or products from a specific application of an M&S. The M&S User is a Government entity.

PROBLEM DOMAIN. Aspects of reality that an M&S supplies at a particular fidelity in order to address a particular purpose (e.g., command and control, attrition, movement, and maneuver).

REQUIREMENTS TRACEABILITY. The degree to which a relationship can be established between the M&S requirements, associated acceptability criteria for accreditation, and evidence collected during verification and validation implementation.

SIMULATION DOMAIN. Aspects of an M&S related to the implementation environment (e.g., time management, object interaction control, M&S User interfaces, databases, report generators).

SUBJECT MATTER EXPERT. An individual who, by virtue of education, training, or experience, has expertise in a particular technical or operational discipline, system, or process.

M&S USER DOMAIN. The realm of knowledge describing an M&S User's environment to which an M&S will be applied.

VALIDATION. The process of determining the degree to which an M&S and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model. The process of determining the fitness of an M&S and its associated data for a specific purpose.

VERIFICATION. The process of determining that an M&S implementation and its associated data accurately represent the developer's conceptual description and specifications. The process of determining that an M&S faithfully represents the developer's conceptual description and specifications. Verification evaluates the extent to which the M&S has been developed using sound and established software and system engineering techniques.

VERIFICATION AND VALIDATION (V&V) AGENT. The individual, group, or organization designated by the M&S Proponent to verify and validate an M&S. The V&V agent provides information to the Accreditation Agent to support the recommendation to accredit an M&S for a specific purpose. The organization designated by the M&S Proponent to perform verification and validation of an M&S.

7 REFERENCES

This section provides the reader with information about applicable policy, guidance, and implementation documents. These references should be used as a starting point to find additional information about management, development, and VV&A standards, practices, and procedures.

7.1 M&S and VV&A Directives and Instructions

- 1) Department of Defense Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 4 January 1994.
- 2) Department of Defense Instruction 5000.61, DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), 12 May 2003.
- 3) Secretary of the Navy Instruction 5200.38A, Department of the Navy Modeling and Simulation Management, 28 February 2002.
- 4) Secretary of the Navy Instruction 5200.40A, Verification, Validation, and Accreditation (VV&A) of Models and Simulations (draft), 3 November 2003.
- 5) Chief of Naval Operations Instruction 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002.
- 6) Commander, Operational Test and Evaluation Force Instruction 5000.1 series, Use of Modeling and Simulation (M&S) in Operational Testing (draft), 16 July 2002.

7.2 Websites

- 1) Air Force Agency for Modeling and Simulation: <http://www.afams.af.mil/>.
- 2) Army Model and Simulation Office: <http://www.amso.army.mil/>.
- 3) Defense Modeling and Simulation Office: <https://dmso.mil/>.
- 4) NAVMSMO: <http://navmsmo.hq.navy.mil/>.

8 ACRONYMS

CM	Configuration Management
COMOPTEVFOR	Commander, Operational Test and Evaluation Force
DoD	Department of Defense
DON	Department of the Navy
M&S	Modeling and Simulation; Model(s) and Simulation(s)
MSEA	Modeling and Simulation Executive Agent
NAVMSMO	Navy Modeling and Simulation Management Office
OPNAV	Naval Operations
OT&E	Operational Test and Evaluation
SECNAVINST	Secretary of the Navy Instruction
SME	Subject Matter Expert
V&V	Verification and Validation
VV&A	Verification, Validation, and Accreditation